

PATENT APPLICATION

Semiconductor Laser Module and Optical Transmitter

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SPECIFICATION

TITLE OF THE INVENTION

SEMICONDUCTOR LASER MODULE AND OPTICAL TRANSMITTER

BACKGROUND OF THE INVENTION

5 The present invention relates to a semiconductor laser module for mounting an optical semiconductor device into an inside thereof, and it also relates to an optical transmitter with using the semiconductor laser module therein.

10 An optical transmitter is used for transmitting a light with using a semiconductor laser therein, wherein a semiconductor module mounting a semiconductor laser is mounted on a substrate for use of heat radiation. For developing such the optical transmitter, it is necessary to obtain incidence and coupling of a light emitted from the semiconductor laser element with high efficiency (i.e., 15 without causing a shift with respect to an optical axis). Relating to this, there are already known the following patent document:

20 Japanese Patent Laying-Open No. Hei 11-74395 (1999) <JP-A 11-74395> mentioned below discloses the module, comprising a frame made of metal, insulating material, or a complex of metal and insulating material, and a first bottom plate fixed on the frame and a second bottom plate fixed on the first bottom plate.

25 Also, Japanese Patent Laying-Open No. Hei 11-163184 (1999) <JP-A 11-163184> discloses therein that the semiconductor laser module is restricted in thickness of a screw portion and the substrate thereof, so as to take countermeasure against mismatching in the position that is caused when screwing the semiconductor

device. And also, Japanese Patent Laying-Open No. 2001-28407 (2001) <JP-A 2001-28407> discloses provision of screw portions, projecting into an outside at a center along a long side of the substrate, so as to prevent the positional alignment of a 5 semiconductor element and an optical fiber from being out of order through the screw fixing. Further, Japanese Patent Laying-Open No. 2001-60735 (2001) <JP-A 2001-60735> discloses the provision of screw portions on both short sides of the substrate, so as to prevent an optical fiber from shifting in the optical axis when 10 being fixed by the screw, and also that an optical fiber fixing member is disposed on one of the long sides of a frame while a reed terminal member on the other side thereof, for the purpose of preventing the optical fiber from shifting in the optical axis thereof when being fixed by the screw, etc. Furthermore, Japanese 15 Patent Laying-Open No. Hei 11-74619 (1999) <JP-A 11-74619> discloses bonding of screw member made of a material, such as, metal, being equal or less than 200 GPa in the Young's modulus and equal or less than 500 MPa in yield stress, on a metal substrate and a metal frame constructing a package for use of an optical 20 semiconductor, while projecting from the metal substrate and the metal frame.

In Japanese Patent Laying-Open No. 2002-72024 (2002) <JP-A 2002-72024>, shifting of the optical axis caused when fixing by the screw is dissolved, by flattening the bottom surfaces of a 25 frame and a flange portion through gliding process.

[Patent Document 1]

Japanese Patent Laying-Open No. Hei 11-74395 (Fig. 1 and the explanation thereof)

[Patent Document 2]

30 Japanese Patent Laying-Open No. Hei 11-163184 (Fig. 1 and the explanation thereof)

[Patent Document 3]

Japanese Patent Laying-Open No. 2001-28407 (Fig. 1 and the explanation thereof)

[Patent Document 4]

5 Japanese Patent Laying-Open No. 2001-60735 (Fig. 1 and the explanation thereof)

[Patent Document 5]

Japanese Patent Laying-Open No. Hei 11-74619 (Fig. 1 and the explanation thereof), and

10 [Patent Document 6]

Japanese Patent Laying-Open No. 2002-72024 (Fig. 1 and the explanation thereof)

However, when mounting a semiconductor laser module on a heat radiation substrate, for building up a semiconductor laser transceiver, for example, and in particular, when driving the laser, the laserelement generates heat, thereby generating thermal stress due to difference in the coefficient of linear expansion between the semiconductor laser module and the substrate for use of heat radiation thereof, and the thermal stress is also generated due 15 to the change of temperature in the environments therearound. As a result of study made by the inventors earnestly, it causes to appear that it is difficult to dissolve the drawbacks, sufficiently, 20 in accordance with the technologies disclosed in the documents mentioned above, such the shifting in the optical axis that is 25 caused due to the thermal stress, which is generated with driving of the laser module.

BRIEF SUMMARY OF THE INVENTION

Therefore, an object according to the present invention is to dissolve such the drawbacks mentioned above.

For dissolving such the drawbacks mentioned above, according to the present invention, the following are proposed, so as to suppress the shifting in the optical axis after installation of 5 the laser module, with high efficiency.

(1) A semiconductor laser module, comprising: a 10 semiconductor laser element; a frame for storing said semiconductor laser element therein; an optical fiber fixing portion being connected to said frame; and a flange being connected to said frame, and having a fixing portion for fixing said frame on a substrate, wherein said flange has a narrow width region between a fixing 15 region, including a fixing portion with said substrate therein; and said frame, and said narrow width region is narrower than width of said fixing region.

(2) The semiconductor laser module, as defined in the above 20 (1), wherein: said frame has a polygonal shape, said flange has a first flange connecting to a first main side of said frame and a second flange connecting to a second main side of said frame opposing to said first main side thereof, said first flange is provided in a first region on said first main side, which is divided by an elongated line of a line connecting a portion where said 25 semiconductor laser element is disposed and a portion where an optical fiber of said optical fiber fixing portion is disposed, while no flange is provided in a second region located on a reverse side of said first region, and no flange is provided in a third region located on the second main side of said frame on a side of said first region, opposing to said first main side, while said second flange is provided in a fourth region located on a side 30 of said second region.

(3) The semiconductor laser module, as defined in the above 20 (1), wherein: said frame has a polygonal shape, said flange has a first flange connecting to a first main side of said frame and

a second flange connecting to a second main side of said frame opposing to said first main side thereof, the connecting portion of said first flange to said frame and said connecting portion of said first flange are disposed in a first region on said first 5 main side, which is divided by an elongated line of a line connecting a portion where said semiconductor laser element is disposed and a portion where an optical fiber of said optical fiber fixing portion is disposed, the connecting portion of said second flange to said frame and said connecting portion of said second flange are disposed 10 in a fourth region, locating at a side of said second region on the second main side of said frame opposing to said first side thereof.

(4) The semiconductor laser module, as defined in the above (1), wherein: said frame has a polygonal shape, said flange has 15 a first flange connecting to a first main side of said frame and a second flange connecting to a second main side of said frame opposing to said first main side thereof, the connecting portion of said first flange to said frame and said fixing portion of said first flange are provided in a first region on said first main 20 side, which is divided by an elongated line of a line connecting a portion where said semiconductor laser element is disposed and a portion where an optical fiber of said optical fiber fixing portion is disposed, and the connecting portion of said second flange to said frame and said fixing portion of said flange are provided 25 in a fourth region located on a side of said second region on the second main side of said frame, opposing to said first main side.

(5) The semiconductor laser module, as defined in the above (1), wherein said fixing region and said narrow width region are so formed that difference between those on a side surface of said 30 flange at a side far from said semiconductor element is larger than that between said fixing region and said narrow width region on the side surface of said flange at a side near to said semiconductor element.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Those and other objects, features and advantages of the present invention will become more readily apparent from the following detailed description when taken in conjunction with the 5 accompanying drawings wherein:

Fig. 1 is a plane view for showing an optical transmitter, according to an embodiment of the present invention;

Fig. 2 is a cross-section view for showing a principle portion of the same optical transmitter;

10 Figs. 3(a) and 3(b) are cross-section views for showing a thermal change in the optical transmitter;

Fig. 4 is an enlarged view for showing a flange portion of a semiconductor laser module, according to the first embodiment of the present invention;

15 Fig. 5 is a cross-section view for showing the principle portion of the optical transmitter, according to the first embodiment of the present invention;

Fig. 6 is a plane view for showing the optical transmitter, according a second embodiment of the present invention;

20 Fig. 7 is also a plane view for showing the optical transmitter, according the second embodiment of the present invention;

Fig. 8 is a cross-section view for showing a principle portion of the optical transmitter, according to a third embodiment of the present invention;

25 Fig. 9 is an enlarged view for showing the flange portion of the semiconductor laser module of the same optical transmitter;

Fig. 10 is a cross-section view of the principle portion of an optical transmitter, according to a fourth embodiment of the present invention;

5 Fig. 11 is a plane view for showing of an optical transmitter, according to a fifth embodiment of the present invention;

Figs. 12(a) and 12(b) are plane views for showing thermal deformation in the optical transmitter; and

Figs. 13(a) and 13(b) are also plane views for showing the thermal deformation in the optical transmitter.

10 **DETAILED DESCRIPTION OF THE INVENTION**

Hereinafter, explanation will be given in a semiconductor laser element and a producing method thereof, according to the respective embodiments of the present invention, by referring to the drawings attached. However, in each of the drawings, for the 15 purpose of preventing them from confusion thereof, illustration is omitted, appropriately, in a portion of some parts and/or adhesive-bonding material, etc. Also, the present invention should not be restricted only to the embodiment disclosed in the present specification, and it should not be prevented from being applied 20 into the conventional technology and that, which is newly created.

<Embodiment 1>

Explanation will be given on an optical transmitter, according to a first embodiment of the present invention, by referring to Figs. 1 to 5. Herein, Fig. 1 is a plane view for showing 25 the optical transmitter according to the first embodiment of the present invention, and Figs. 2 and 5 are cross-section views of the principle portion thereof. Also, Fig. 3(a) is a view for showing the thermal deformation in the optical transmitter of the conventional art, and Fig. 3(b) a view for showing the thermal

deformation in the optical transmitter according to the present embodiment. Also, Fig. 4 is a view for showing an example of notch formed in a flange portion of a the semiconductor laser module, in the optical transmitter according to the present embodiment.

5 In the optical transmitter 1 according to the present embodiment, as is shown in Figs. 1 to 2, a semiconductor laser module 2 is mounted on a substrate for us of heat radiation therefrom (hereinafter, being called by "heat radiation substrate) and is packaged by means of a housing 16. The above semiconductor module 10 2 has a stem 4 mounting a semiconductor laser element 3 thereon, an optical fiber 8 for transmitting a laser light emitted from the semiconductor laser element 3 into an inside, and fiber fixing portions 6 and 7 for fixing the optical fiber on a frame 9, wherein the stem 4 and the frame 9, which are used as the substrate for 15 mounting the semiconductor laser element thereon, are connected with, respectively, through brazing material, such as, silver brazing, etc. Above the upper portion of the semiconductor laser element 3, a frame cover potion 41 is formed covering over the semiconductor laser element 3.

20 Also, the stemmember has a function for effectively directing heat generated by the LD when driving the LD into the heat radiation substrate, and therefore it is preferable to be made of a material having thermally high heat conductivity. However, in general, the material having good heat conductivity has also a large coefficient 25 of linear expansion, therefore if using the material of high heat conductivity as a material of the stem, simply, the difference from the coefficient of linear expansion of the LD comes to be large, thereby generating stress which causes defects in the LD. Then, a material having large heat conductivity and having a small 30 difference with respect to the LD in the coefficient of linear expansion is used as the material of the stem, however such the material is expensive, therefore it is necessary to make such the material as small as possible in an amount of use thereof. In the optical transmitter 1 shown in the embodiment 1, a hole portion

is formed on the substrate, so that the stem is directly connected onto the heat radiation substrate 10, and therefore the heat generated when driving the LD flows from the stem into the heat radiation substrate. Accordingly, it is not necessary to use such 5 a material having large one as that of the stem, in the heat conductivity thereof, as a material of the substrate; therefore it is possible to save the material cost, thereby resulting into cost reduction.

Also, a reed terminal 14 is provided for electrical connection 10 between the semiconductor laser element 3 and an outside circuit, and this reed terminal 14 is fixed on a side surface of the frame 9 through an insulating material 13, such as, aluminum oxide, etc.

Also, on a side surface of the frame 9 are formed flanges 11 for connecting the substrate (for example, the heat radiation 15 substrate 10) and the semiconductor module 2 by means of a screw 17 as the fixing member, on which a tapped hole 12 is formed as a fixing portion. The substrate 10 has a substrate cover portion 42 covering over the frame 9, in the above thereof.

The semiconductor module 2 mounting the optical transmitter 20 1 thereon has a notch 15 for defining a narrow width region, which is formed in a root or base portion of the flange mentioned above, as shown in Fig. 1. With forming of this notch in the base portion of that flange, thereby forming the narrow width region, the 25 rigidity of the base portion mentioned above is made to be smaller than those of the said substrate and the said frame, with respect to deforming in the horizontal direction along with the substrate 10. Herein, the rigidity mentioned above indicates a difficulty of movement of a point "d" while keeping points "a" and "b" fixed, in assuming that the point "d" is a center of a boundary portion 30 between the flange base portion and the frame, and that "b" and "c" are at the points where a straight line, being orthogonal to an optical axis passing through the point "a" at the most nearest to the frame in the vicinity of the screw 17 shown in Fig. 4, comes

across a side portion of the flange portion.

The flange 11 has the narrow width region between a fixing region, including therein the fixing portion with the heat radiation substrate 10, and the frame 9, being narrower than the 5 fixing region mentioned above.

Fig. 3(a) shows the thermal deformation in an optical transmitter having no such the narrow width region in the flange thereof, as a comparison example, and Fig. 3(b) the thermal deformation in the optical transmitter comprising the narrow width 10 region, according to the present embodiment mentioned above. In the conventional optical transmitter 1a, as is shown in Fig. 3(a), the semiconductor laser module 2 tries to deform or bend downward in a concave-like manner or shape due to the difference in the coefficient of linear expansion between the iron-nickel-cobalt 15 alloy ($\alpha_1 = 5.3 \times 10^{-6}/C^\circ$) building up the frame 9 and CuW ($\alpha_2 = 8.3 \times 10^{-6}/C^\circ$) building up the stem, when environmental temperature is high in the use thereof, or when the semiconductor laser element 20 is driven, thereby generating heat therefrom. And further, the heat radiation substrate 10 ($\alpha_3 = 23 \times 10^{-6}/C^\circ$) also tries to deform or bend downward due to the difference in the coefficient of linear 25 expansion from the semiconductor module 2. In addition thereto, since also rotary moment is added onto the frame in the horizontal direction along the substrate, the deformation of the frame 9 comes to be large if not possible to absorb that rotary moment, thereby causing difference in position between the laser emission direction 19a and the fiber connect direction 19b (i.e., an optical axis shifting 24).

On the other hand, in the optical transmitter according to the present invention, as is shown in Fig. 3(b), because of forming 30 of the notch 15 in the flange portion, the rigidity of the flange is weak, in particular, to the rotary moment in the horizontal direction along the substrate, on which the flange is fixed. With

this, the flange base portion 23 absorbs the deformation due to the rotary moment, and therefore it is possible to suppress the semiconductor module 2 from being promoted in bending thereof. And according to this, the frame can be prevented from such the 5 deformation, and the direction of laser emission and the fiber connection direction are combined or aligned with each other, thereby protecting the optical axis from generating the shifting therein.

In the similar manner, in the case where the temperature 10 is high in the environment of use of the optical transmitter 1, the semiconductor module 2 tries to deform or bend upward in a convex-like shape, and further, also the heat radiation substrate 10 tries to deform or bend upward in the convex-like shape due to the difference in the coefficient of linear expansion of the 15 semiconductor module 2, thereby generating a rotary moment in the opposite direction thereof. However, since the notch 15 is formed in the flange portion, the rotary moment mentioned above is absorbed, sufficiently, by means of the flange having the narrow width region in the flange base portion 23, and the semiconductor module 2 can 20 be prevented from being promoted in bending, with an aid of bending of the heat radiation substrate 10, thereby protecting the optical axis from shifting therein.

Also, as is shown in Figs. 1 and 4, it is preferable to form the notch on the opposite side of the flange with respect to the 25 optical axis 9. Thus, a connecting portion of the flange with the frame 9 is formed on the side near to the optical axis 9. With this, the deformation can be made easily, in particular, in the narrow width region, i.e., the flange base portion 23, thereby increasing an effect of preventing the optical axis from shifting 30 thereof. In the case where the notches are formed on both side of the flange, it is preferable that a larger one is formed on the opposite side of the flange with respect to the optical axis 9 mentioned above. Therefore, the fixing region and the narrow width region are formed, so that the difference between them formed

on a side surface of the flange 11 at the side far from the semiconductor laser element 3, is larger than that formed on a side surface of the flange 11 at the side near to the semiconductor laser element 3. Herein, the fixing region has a distance L_3 measured 5 by passing through at the maximum diameter of the tapped hole 12 as the fixing portion, and the length of the narrow width region can be made to be L_2 .

Also, as is shown in Fig. 4, assuming that a length of the notch formed at the base portion of the flange is L_1 , and that 10 a length of the base portion of the flange is L_2 , then it is preferable that the notch length of the flange satisfies a relationship, i.e., $L_1 > L_2$. With this, the rigidity of the flange base portion comes down, sufficiently, so that it can be deformed easily, thereby increasing an effect of preventing the optical axis from shifting. 15 However, if $L_2 < 0.5L_1$, the rigidity comes down to be weak too much at the flange base portion, and there may occur a possibility that the flange fails to achieve the function of fixing the semiconductor laser module on the heat radiation substrate. If power for fixing the semiconductor laser module onto the heat 20 radiation substrate is too weak, contacting power between a bottom surface of the stem and that of the substrate goes down, and it increases thermal resistance from the stem bottom surface to the substrate, thereby lowering an effect of radiating the heat of the laser element. Therefore, it is preferable that the length 25 L_2 of the flange base portion is $L_2 > 0.5L_1$. For example, in a case where the width of the flange is 3mm, it is enough that $1mm \leq L_1 \leq 1.5mm$.

It is also preferable that thickness at the flange base portion is equal or less than one-twelfth (1/12) of the length 30 of a long side of the frame. For example, if the long side length of the frame is 12mm, preferably, the thickness is equal or less than 1mm. With this, the flange base portion 23 can be deformed easily, thereby increasing the effect of preventing the optical

axis from being shifted. However, also in case of being too thin, the flange base portion comes to be too weak in the rigidity, therefore there occurs a possibility that the flange loses the function of fixing the semiconductor laser module on the heat 5 radiation substrate, therefore it is needed that the thickness of the flange at the base portion thereof is equal to or greater than 1/24 of the long side length of the frame. This means that, it must be equal or greater than 0.5mm, if the frame long side is 12mm in length.

10 Also, in this case, it is preferable to form the fixing region at the position, where the tapped hole 12 is disposed, to be thicker than others.

Also, the frame 9 has a square or quadrilateral shape or a polygon shape, mainly. It has a first flange 11 connecting to 15 a first main side of the frame 9, which has a connecting portion of the optical fiber, and a second flange 11 connecting to a second main side of the frame 9, opposing to the first main side. The first flange 11 is provided in a first area (A1) on the first main side, which is divided by an elongated line of that connecting 20 between the semiconductor laser element 3 and a portion where the optical fiber of the optical fiber fixing portion 6 is disposed, while no flange is provided in a second area (A2) located at opposite side of the first area mentioned above and a third area (A3) located on a side of the first area on the second side of the frame, and 25 then a second flange is provided in a fourth area (A4) located on a side of the second area.

It is also preferable that, the bottom surface 21 of the frame contacting with the heat radiation substrate 10, the bottom surface 22 of the flange, and the bottom surface 20 of the stem 30 are machined to be flat to be equal or less than 4 μm in flatness thereof. It can be machined through, such as, the gliding process, for example. In this case, in particular when the frame 9 and the stem 4 are bonded with the brazing material, such as, silver brazing,

etc., even if bending occurs on the bottom surface of module, which is made up with the frame bottom surface 21, the stem bottom surface 20 and the flange bottom surface 22, due to the temperature difference from a melting point of the silver brazing (i.e., 780°C) 5 down to a room temperature and the difference in the coefficient of linear expansion between the frame 9 and the stem 4 (in case that the frame is made of iron-nickel-cobalt alloy and the stem of copper-tungsten alloy, bending upward in a convex manner), however according to the semiconductor module of the optical 10 transmitter according to the present invention, since the bottom surface of the module is machined to be flat after connecting the frame 9 and the stem 4 through silver brazing, as was mentioned in the above, no bending stress is applied onto the semiconductor module, even when being fixed onto the heat radiation substrate 15 by the screw, therefore the optical axis thereof is prevented from shifting.

Also, according to the present embodiment, though showing a case where two (2) pieces of flanges are used for fixing by the screw, as the semiconductor module 2 fitted to small-sizing of the optical transmitter, however according to the present invention, the similar effect can be obtained, by adjusting the thickness and/or the width of the flange base portion, which will be shown later, if the flanges are three (3) or more in the number thereof. 20

Next, assuming that the coefficients of linear expansion 25 of the frame 9, the stem 4 and the heat radiation substrate 10 are α_1 , α_2 and α_3 , respectively, then explanation will be given on each of the cases, when a relationship is established in the magnitude thereof in among them.

(1) In a case where $\alpha_1 < \alpha_2 < \alpha_3$ (or, $\alpha_1 > \alpha_2 > \alpha_3$), explanation 30 will be given, by referring to Fig. 4. When such the relationship (i.e., $\alpha_1 < \alpha_2 < \alpha_3$ (or, $\alpha_1 > \alpha_2 > \alpha_3$)) as was mentioned above can be established in the coefficients of linear expansion is a case

where, for example, the frame 9 is made of iron-nickel-cobalt alloy (i.e., the iron-nickel-cobalt alloy, $\alpha_1 = 5.3 \times 10^{-6}/^\circ\text{C}$), the stem is made of copper-tungsten alloy (i.e., CuW, $\alpha_2 = 8.3 \times 10^{-6}/^\circ\text{C}$), and the heat radiation substrate 10 is made of aluminum (i.e., $\alpha_3 = 23 \times 10^{-6}/^\circ\text{C}$).

Also, as is shown in Fig. 5, it is effective to provide a member being smaller than the frame 9 in rigidity (a low rigidity high heat conduction member 25), such as, of heat conductive grease and/or heat conductive elastomer, etc., having heat conductivity being equal or greater than 2W/mK , between the stem bottom surface 22 and the heat radiation substrate 10, for increasing the heat conductivity between the both members.

It is also effective to rise up pressure weight of the semiconductor laser module onto the substrate, by making the cover of the optical transmitter thick in a part thereof. However, in this case, it is preferable to provide a low rigidity high heat conductive member 27, such as, elastomer, etc., between the semiconductor laser module and the thick portion of the cover 26, so as to prevent the weight much more than the desired from applying between the semiconductor laser module and the substrate.

<Example 2>

Explanation will be given on other embodiment, by referring to Figs. 6 and 7.

Basically, although it is possible to make the present embodiment being same to the optical transmitter 28 of the embodiment 1, shown in Fig. 1, however it differs in the shapes of an attachment portion 30 of a flange for use of screwing, for the purpose of attaching the semiconductor laser module 29 and the heat radiation substrate 10 by a screw, and also of a flange 31.

The semiconductor laser module 29 mounted on the optical transmitter according to the present embodiment has, as is shown in Fig. 6, a first flange connecting to the first main side of the above-mentioned frame 9, a second flange connecting to the 5 second main side of the frame 9, but opposing to the first main side thereof, and further comprises a tapped hole 32 as a fixing portion of the first flange in a first area (A1) of the first main side, which is divided by a line elongating from that connecting between the semiconductor laser element 3 and a portion where the 10 optical fiber at the optical fiber fixing portion 6 is disposed, a connection portion to the frame 9 of the first flange in a second area (A2) located on an opposite side of the first area, and a fixing portion of the second flange mentioned above in a fourth area (A4) located on a side of the second area. Thus, a base portion 15 of the flange mentioned above is formed in a space, to which the tapped hole of the flange belongs, between the two (2) spaces divided into two (2) by a plane, passing through the optical axis of the above-mentioned semiconductor laser element and being vertical to the heat radiation substrate, and on a frame side wall parallel 20 to the optical axis.

The attachment portion of the flange onto the frame is located at a position other than portions (assuming to be a portion A and a portion A') where the vertical lines extending to sidewalls of the frame from the tapped holes formed on the flange portions comes 25 across the sidewalls of the frame, on the nearest sidewall from the tapped hole 32 formed on the flange portion. In Fig. 6, the attachment portion 30 of the flange to the frame is provided at the position extending over an optical fiber fixing portion 6, on the sidewall same to the portion A and the portion A'.

30 As is also shown in Fig. 7, attachment portions 33 of the flange to the frame are provided on the sidewall being different from the portion A and the portion A'. As is shown in Figs. 6 and 7, further it is possible to elongate the flange, with provision of the flange base portion at a location far from the portion A

and the portion A', and with this, in addition to the function and the effect of the embodiment 1, the flange base portion can be deformed, easily, even if the heat radiation substrate is deformed, thereby increasing the effect of preventing the optical axis from shifting.

And, also in this case, as was mentioned in the explanation about the embodiment 1, forming the notch at the flange base portion and/or making the flange base portion thin in the thickness thereof effectively enhance the effect of suppressing the shifting in the optical axis.

Also, as was shown in the embodiment 1, for the purpose of increasing adherence between the semiconductor module and the heat radiation substrate, it is preferable to provide a member, having good heat conductivity and low rigidity, such as elastomer, etc., for example, between the module and the substrate.

<Example 3>

Explanation will be given on other embodiment, by referring to Figs. 8 and 9.

The semiconductor laser module 35, which is mounted on the optical transmitter 34 according to the present embodiment, has a flange 36, as shown in Fig. 8, being thicker than the thickness of the bottom plate portion of the semiconductor laser module 35 connecting to the frame 9, thereby having high rigidity at the flange 36. Since the flange portion is thick in the thickness and has high rigidity, the force due to bending of the heat radiation substrate is transmitted to the semiconductor laser module, easily. With this, in addition to the effect obtained by the embodiment 1, it is possible to suppress the deformation of the semiconductor laser module, and thereby inhibit the shifting of the optical axis.

In the present embodiment, preferably, they are constructed

so as to establish the following relationship; $\alpha_2 < \alpha_1$, $\alpha_2 < \alpha_3$, (or $\alpha_2 < \alpha_1$, $\alpha_2 < \alpha_3$). An example, satisfying such the relationship among the coefficients of linear expansion (i.e., $\alpha_2 < \alpha_1$, $\alpha_2 < \alpha_3$ (or $\alpha_2 < \alpha_1$, $\alpha_2 < \alpha_3$), is in such a case, where the frame is made 5 of aluminum ($\alpha_1 = 23 \times 10^{-6}/^\circ\text{C}$), the stem is made of copper tungsten alloy ($\alpha_2 = 8.3 \times 10^{-6}/^\circ\text{C}$), and the heat radiation substrate is made of aluminum ($\alpha_3 = 23 \times 10^{-6}/^\circ\text{C}$), for example.

In a case where the environment temperature is high, in which the optical transmitter 34 is used, or in a case where the 10 semiconductor laser element 3 is driven, the semiconductor laser module 35 tries to deform or bend upward in convex-like shape, due to the difference in the coefficient of linear expansion between the aluminum ($\alpha_1 = 23 \times 10^{-6}/^\circ\text{C}$) building up the frame and CuW ($\alpha_2 = 8.3 \times 10^{-6}/^\circ\text{C}$) building up the stem. However, since the coefficient 15 of linear expansion α_3 of the heat radiation substrate is larger than that α_1 of the stem, then it bends upward in convex-like shape so as to cancel the bending of the semiconductor laser module 2 upward in convex-like shape. Herein, since the flange portion is thick in the thickness and it has high rigidity, the force due 20 to the bending of the heat radiation substrate can be transmitted, easily to the semiconductor laser module. With this, it is possible to suppress the deformation of the semiconductor laser module, thereby inhibiting the shifting in the optical axis.

In the similar manner, in a case where the environment 25 temperature is low in use of the optical transmitter 34, the semiconductor laser module 35 tries to deform or bend downward in convex-like shape, due to the difference in the coefficient of linear expansion between the aluminum ($\alpha_1 = 23 \times 10^{-6}/^\circ\text{C}$) building up the frame and CuW ($\alpha_2 = 8.3 \times 10^{-6}/^\circ\text{C}$) building up the stem, while 30 since the coefficient of linear expansion α_3 of the heat radiation substrate is larger than that α_1 of the stem, the heat radiation

substrate bends upward in convex-like shape, thereby canceling the bending of the semiconductor laser module 2 downward in convex-like shape. Herein, since the flange portion is thick in the thickness and it has high rigidity, the force due to the bending 5 of the heat radiation substrate can transfer, easily to the semiconductor laser module. With this, it is possible to suppress the deformation of the semiconductor laser module, thereby inhibiting the shifting in the optical axis.

Also, as is shown in Fig. 9, so as to enhance the effect 10 of suppressing the deformation in the semiconductor laser module, it is preferable to satisfy the relationship; $L_4 > L_3$, if assuming that L_3 is the thickness of the bottom plate portion 37 of the semiconductor laser module and L_4 the thickness of the flange. It is also preferable that the thickness of the bottom plate portion 15 37 is equal or less than 2mm. With this, the stem can be fixed strongly, thereby enhancing the effect of inhibiting the shifting in the optical axis.

<Example 4>

Explanation will be made on other embodiment, by referring 20 to Fig. 10.

The present embodiment differs from the optical transmitter 28 according to the embodiment 1, which is shown in Fig. 1, in particular, in the mounting method of the stem on a substrate. In the optical transmitter 1 shown in the embodiment 1, the hole 25 portion is formed on the substrate, so as to connect the stem on the heat radiation substrate 10, directly. On the contrary thereto, the stem 4 of the optical transmitter according to the present embodiment, which is shown in Fig. 11, is bonded on the heat radiation substrate 10 through the substrate 5. With this, since the substrate 30 5 has no hole portion therein, it is possible to bring the rigidity of the substrate to be larger than that of the substrate shown in the embodiment 1, enabling reduction in the thermal deformation

of the substrate 5 generated due to the difference in the coefficient of linear expansion between the heat radiation substrate and the semiconductor laser module, and thereby enabling to suppress the shifting in the optical axis. Also, with the flange portion, since 5 the cut portion (or a notch) is formed in the similar manner to the embodiment 1, therefore it is possible to inhibit the shifting in the optical axis through the mechanism being similar to that in the embodiment 1.

<Embodiment 5>

10 Further other embodiment will be explained by referring to Figs. 11 to 13.

15 The present embodiment differs from the optical transmitter 28 according to the embodiment 1, which is shown in Fig. 1, and the optical transmitter 38 according to the embodiment 4, which is shown in Fig. 10, in particular, in the number of flanges for use in screwing the semiconductor laser module onto the heat radiation substrate.

20 The semiconductor laser module 40, which is mounted on the optical transmitter 39 according to the present embodiment, has flange portions, as shown in Fig. 11, at the base portion of each of which is formed the notch 15 for defining the narrow width region. With forming the narrow width region through the notch at the base portion of the flange mentioned above, the rigidity of the base portion mentioned above is made to be smaller than those of the 25 substrate and the frame mentioned above, in particular, to the deformation caused in the horizontal direction along the substrate 10.

30 Due to this, even if the thermal deformation is caused on the semiconductor laser module 40, accompanying the driving of the semiconductor laser and the changing of environment temperature thereof, due to the difference in the coefficient of linear

expansion between the heat radiation substrate 10 and the semiconductor laser module 40, the thermal deformation mentioned above is absorbed at the flange base portion; therefore it is possible to prevent the thermal deformation from reaching to the 5 frame. With this, the shifting in the optical axis can be prevented, which is caused when driving the semiconductor laser, and also accompanying the changing of the environment temperature thereof.

Explanation will be given on the effect of absorbing the thermal deformation at the flange base portion shown in the above, 10 by referring to Figs. 12(a) and 12(b) and Figs. 13(a) and 13(b). Figs. 12(a) and 12(b) are views for showing the thermal deformation caused when driving the semiconductor laser of the optical transmitter according to the present embodiment, and also due to the changing of the environment temperature thereof, and in 15 particular, Fig. 12(a) shows that before deformation occurs while Fig. 12(b) after deformation. Herein, there is provided a heat radiation substrate 10, a semiconductor laser module 40, and also flanges 44a, 44b, 44c and 44d for use in attaching those mentioned above by means of screws 17. Also, there is provided a main portion 20 where the semiconductor laser element of the semiconductor laser module 40 is mounted on. Herein, for convenience of explanation, parts other than those mentioned above are omitted from the drawing. In the optical transmitter according to the present invention, 25 each of the flanges 44a, 44b, 44c and 44d is provided with the notch at the connection portion with the main body of the semiconductor laser module. Also, the notch mentioned above is formed in the flange base portion, in particular, on a side at a corner portion of the module main body. Also, Figs. 13(a) and 13(b) show the thermal deformation caused when the semiconductor 30 laser is driven, and also due to the changing of the environment temperature thereof, on the optical transmitter having no such the notch in the flanges 45a, 45b, 45c and 45d, as a comparison example, and in particular, Fig. 13(a) shows that before deformation occurs while Fig. 13(b) after deformation. Also, any 35 one of the figures showing the deformation mentioned above shows

an example of the thermal deformation in the case where the coefficient of linear expansion of the heat radiation substrate is larger than that of the frame of the semiconductor laser module (in a case where the heat radiation substrate made of aluminum 5 is $26 \times 10^{-6}/^{\circ}\text{C}$ in the coefficient of linear expansion and the frame made of iron-nickel-cobalt alloy $5.3 \times 10^{-6}/^{\circ}\text{C}$ in the coefficient of linear expansion, for example), and when the temperature goes down from high to low.

First of all, in the case there is formed no such notch in 10 the flange, as shown in Fig. 12(b), since the heat radiation substrate is large in an amount of heat shrinkage, comparing to that of the semiconductor laser module, the distance is reduced between the flanges 44a and 44b and between the flanges 44c and 44d. Accompanying with this, the module main body 43 is dragged 15 at the corners 101, thereby deforming. With this deforming, strain is produced in the module main body 43, and as a result of this, causing the shifting in the optical axis.

On the other hand, also in the case there is provided the notch in the flange, as is shown in Fig. 13(b), since the heat 20 radiation substrate is large in an amount of heat shrinkage, comparing to that of the semiconductor laser module, the distance is reduced between the flanges 45a and 45b and between the flanges 45c and 45d. However, because of forming the notches 15 in the flanges 45a, 45b, 45c and 45d, there occurs no sliding at the corners 25 of the module main body, and therefore stress hardly occurs in the body of the frame 9. As a result of this, the shifting in the optical axis can be suppressed. Also, because the notch is formed in the flange base portion, in particular, on the side at the corner 100 of the module main body, it brings about the effect of suppressing 30 the deformation of the module main body, thereby being effective to prevent the shifting in the optical axis.

As was fully explained in the above, according to the present invention, it is possible to prevent the shifting in the optical

axis of the semiconductor laser module due to the thermal stress, effectively.

The present invention may be embodied in other specific forms without departing from the spirit or essential feature or 5. characteristics thereof. The present embodiment(s) is/are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the forgoing description and 10. range of equivalency of the claims are therefore to be embraces therein.